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APPLICATION
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LETTERS PATENT

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FOR: ELECTRIC TERMINAL FOR AN ELECTRONIC DEVICE

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ELECTRIC TERMINAL FOR AN ELECTRONIC DEVICE

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to an electric terminal for an electronic device and, more particularly, to the structure of an electric terminal for use in an electronic device and having a higher connection reliability. The present invention also relates to a method for forming such an electric terminal.

(b) Description of the Related Art

The reliability of an electronic device often depends on the connection reliability of the electric terminals used in the electronic devices. Figs. 1A to 1D show conventional electric terminals used in semiconductor devices, which are to be mounted on respective printed circuit boards (mounting board) by using a flip-chip bonding technique. Figs. 2A to 2D corresponding to Figs. 1A to 1D, respectively, show the electric terminals after the heat cycle tests thereof.

Fig. 1A shows the basic structure of the flip-chip bonding terminal called C4 type, wherein an external electrode implemented by a solder ball 32 formed on an

electronic device 31 is mounted on a pad 34 of a printed circuit board 33, and is melted thereon for bonding.

In general, after the melting and subsequent cooling steps of the mounting process, an under-filling process is conducted wherein the space between the electronic device 31 and the printed circuit board 33 is filled with resin, which is then subjected to a curing step. The under-filling process improves the reliability of the bonding structure during the subsequent heat cycle test by diversifying the thermal stress applied onto the bonding structure during the heat cycle test. The heat cycle test is likely to cause a crack 38 in the solder ball 32, such as shown in Fig. 1B.

The is a problem in the basic structure of the flip-chip bonding structure of Fig. 1A that the under-filling step increases the fabrication steps and thus raises the cost of the electronic device. In addition, the smaller pitch of the arrangement for the external terminals of the up-to-date electronic device due to the higher integration of the semiconductor devices renders the under-filling step itself difficult.

Figs. 1B to 1D are improved conventional flip-chip bonding structures devised or proposed in view of the above problems in the basic structure shown in Fig. 1A.

In Fig. 1B, an interposer substrate or sheet 35 is interposed between the electronic device 31 and the solder

ball 32 for alleviating or absorbing the stress. The electric connection between the electronic device 31 and the solder ball 32 is implemented by an interconnecting wire or an inner lead of a tape automated bonding (TAB) structure.

It is difficult to use the interposer substrate 35, however, for an electronic device having higher-density terminals because of the difficulty in arranging a large number of interconnecting wires with a higher density. In addition, the thermal expansion of material used for the interposer sheet may damage the bonding structure to cause a crack 38 in the solder ball, as shown in Fig. 2B.

In Fig. 1C, a conductive post or pole 36 such as made of Cu is formed on the electronic device 31, and the solder ball 32 is disposed on the top of the conductive post 36. The conductive post 36 should have a diameter sufficient for supporting the solder ball 32 and a height sufficient for absorbing the stress.

It is difficult, however, to design the diameter and the height of the conductive post 36 because a trade-off resides between the handling or testing of the electronic device and the reliability for the bonding structure of the electronic device. More specifically, the handling or testing step requires a larger diameter and a smaller height of the conductive post 36 to have a sufficient mechanical strength, whereas a higher reliability in the bonding structure requires

a smaller diameter and a large height of the conductive post 36 for absorbing the thermal stress to avoid a crack 38 in the solder ball 32 (Fig. 2C).

In Fig. 1D, a conductive spring or wire 37 is used instead of the solder ball 32 for achieving a higher density of the external terminals. The surface of the wire 37 is coated with a thick plating film for achieving a sufficient mechanical strength and resilience.

INS A1

~~The wires 37, however, have a lower allowance for a misalignment in arrangement of the terminals and for the ununiformity in the height of the terminals, i.e., for the coplanarity in arrangement of the terminals, compared to the solder balls which allow a relatively large deviation in the arrangement and the height. This lowers the product yield of the electronic devices having such wires 37 irrespective of employing a BGA structure for the electric terminals.~~

SUMMARY OF THE INVENTION

In view of the above problems in the conventional techniques, it is an object of the present invention to provide an electric terminal for use in an electronic device.

It is another object of the present invention to provide a method for forming such an electric terminal on an electronic device.

The present invention provides an electric terminal for

an electronic device including: an external electrode; a lead member disposed on an internal electrode of the electronic device, at least a portion of the lead member being a conductor connecting the external electrode and the internal electrode; and a support member disposed on the electronic device in the vicinity of the lead member for supporting the external electrode at least upon application of an external thrust force which deforms the lead member.

The present invention also provides a method for forming an electric terminal on an electronic device including the steps of: forming a lead member on an internal electrode of the electronic device; forming an external electrode on the lead member; and forming a support member on the electronic device in a vicinity of the lead member, the support member being in contact with the external electrode at least upon application of an external force which deforms the lead member.

In accordance with the electric terminal of the present invention and the electric terminal manufactured by the method of the present invention, by separating the lead member having an electric connection function of the electric terminal from the support member having a mechanical supporting function of the electric terminal, a reliable electric connection can be obtained after a heat cycle test for the electronic device.

The above and other objects, features and advantages of the present invention will be more apparent from the following description, referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A to 1D are sectional views of conventional electric terminals.

Figs. 2A to 2D show after heat cycle tests for the conventional electric terminals of Figs. 1A to 1D, respectively.

INS A2

~~Fig. 3 is a sectional view of an electric terminal according to an embodiment of the present invention.~~

Fig. 4 is a sectional view of the electric terminal of Fig. 1 after mounting the electronic device on a printed circuit board.

INS A3

~~Figs. 5A and 5B are sectional views showing the electric terminal of Fig. 1 during a heat cycle test thereof.~~

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PREFERRED EMBODIMENTS OF THE INVENTION

Now, the present invention is more specifically described with reference to accompanying drawings.

Referring to Fig. 3, an electric terminal, generally designated by numeral 10, according to an embodiment of the present invention is formed on an electronic device 11 such

as an LSI. The electric terminal 10 includes a solder ball or external electrode 12, an elongate lead member 13 for electrically connecting the solder ball 12 to a pad 16 of the electronic device 11, and a support member 14 for mechanically supporting the solder ball 12 on the surface of the electronic device 11.

The lead member 13 has a resilience and thus absorbs the thermal stress occurring during a heat cycle test due to a difference in the thermal expansion coefficient between the electronic device 11 and a printed circuit board (not shown) on which the solder ball 12 is to be mounted. The lead member 13 is preferably made of a conductive material such as a metallic wire, or may be made of an insulator body, such as a resist bump, coated with a conductive film.

The support member 14 surrounds the lead member 13, and has a function for preventing an excessive deformation of the lead member 13 during an electrical test step of the electronic device 11, wherein the solder ball 12 is applied with a thrust force by a probe pin, by maintaining the location of the solder ball 12 within a specified range.

The support member 14 also has some extent of resilience and thus prevents the solder ball 12 from being applied with an excessive, local stress concentration. The support member 14 is preferably made of an insulator film patterned by a photolithographic patterning technique.

In the structure of the first embodiment, since the mechanical structure for supporting the external electrode 12 with respect to the electronic device 11 is physically separated from the electric element for electrically connecting the external electrode 12 to the electronic device 11, both the reliability of the electric connection against a damage by the thermal stress and the mechanical strength necessary for handling and testing the electronic device can be achieved.

The term “electronic device” as used herein includes a single LSI chip such as called flip-chip, and a variety of types of semiconductor packages including a chip scale package generally fabricated by a wafer-level packaging technique. The chip scale package is such that an interconnect layer formed on an array of chip electrodes is provided thereon with another array of external electrodes.

The lead member 13 may be made of any material or materials and may have any dimensions, so long as the lead member 13 effectively connects the electronic device 11 to the printed circuit board via the solder ball 12 and has a flexibility for deformation upon application of a stress thereto.

Ins A4

~~For example, the lead member 13 may be a conductor~~ post disposed on ~~the electronic~~ device 11, or may be a ~~conductor~~ post formed by selectively plating the surface of

A4 Cont

the electronic device 11. In addition, the lead member 13 may be a conductor post formed separately from the electronic device 11 and then disposed on the electronic device 11, a conductor post formed by etching a metallic film, a conductor post formed by a wire bonding technique, or a metallic wire coated with an insulator film. Further, the lead member 13 may be a conductor bump, at least a portion of which is made of solder, or an insulator post having a central hole filled with a conductor by using, for example, a plating technique.

In the present embodiment, a solder ball is used as the external electrode 12. However, the external electrode 12 may have any structure or any dimensions, so long as the external electrode 12 is bonded to the pad of the printed circuit board by using a thermally melting technique. For example, the external electrode 12 may have a Cu core having a solder coat at least on a portion of the surface thereof. In some cases, solder may be provided onto the printed circuit board or mounting board without providing solder to the external electrode.

The external electrode 12 may have a core ball made of a conductor material or conductor materials and coated with a solder, the core ball having a higher melting point compared to the solder coat. The core ball may be made of a conductor ~~shell receiving therein an insulator sub-core.~~

The supporting member 14 may preferably be made of

an insulator. The supporting member 14 need not entirely surround the lead member 12: for example, the supporting member 14 may be a combination of four insulator poles disposed radially outside the central lead member 13. The supporting member 14 need not contact the surface of the solder ball 12 when no external force is applied between the solder ball 12 and the supporting member 14. At least a par of the supporting member 14 may be made of a conductor or metal which may be formed on the chip electrode, whereby the supporting member has 14 a higher mechanical strength and effectively supports the solder ball 12.

The supporting member 14 may be an insulator film patterned by a photolithographic technique, or a resin body which is configured by a transfer molding technique and may be patterned to have a specified shape by using a laser etching, wet etching or dry etching technique.

Ins A5

~~The supporting member 14 may include an insulator film or plate having a central through-hole filled with a conductor plug after the insulator film is attached onto the electronic device. In an alternative, the insulator film or plate of the supporting member may be attached onto the electronic device before forming therein the through-hole.~~

Referring to Fig. 4, it is shown that a semiconductor circuit (electronic device) 11 having a plurality of external terminals according to the above embodiment is mounted on a

printed circuit board 15. The arrows illustrated in Fig. 4 indicate the stresses when the semiconductor device 11 and the printed circuit board 15 are subjected to a higher temperature. As shown therein, the printed circuit board 15 has a higher thermal expansion coefficient compared to the semiconductor device 11. Thus, the external terminals 10 disposed at the outermost sides of the semiconductor device 11 are subjected to highest thermal stresses.

Each of the solder balls 12 disposed at the outermost sides shown in the figure is subjected to a highest thermal stress applied in the outer direction, and thus shifted slightly toward the outer side with respect to the semiconductor device 11 including the support member 14, without involving a disconnection between the solder ball 12 and the lead member 13 or without a crack in the lead member 13.

Figs. 5A and 5B show the situations of the external terminal 10 of the present embodiment during the heat cycle test, wherein Fig. 5A shows the situation during a lower temperature whereas Fig. 5B shows the situation during a higher temperature. The solder ball 12 is moved in the horizontal direction during the heat cycle due to the flexibility of the lead member 13 and the support member 14 without a damage in the electric connection.

In the configuration of the electric terminal of the present embodiment, the under-filling step is unnecessary for

the bonding structure because the electric terminal is not damaged by the heat cycle test due to the function of the lead member and the support member.

Since the above embodiments are described only for examples, the present invention is not limited to the above embodiments and various modifications or alterations can be easily made therefrom by those skilled in the art without departing from the scope of the present invention.